allow this information to be broadcast in specialized formats or languages for specialized audiences.

3.5 Kiosk Centers for Video Reception

There is a growing kiosk phenomenon in the U.S., which SpaceCast™ will support. Specialized video programming is being increasingly distributed to locations such as terminals, waiting rooms, and schools, designed for the particular makeup and circumstances of the audiences at these sites. These "kiosk" reception centers will increase in popularity as advertisers and content distributors take greater advantage of new technologies such as SpaceCast™.

In addition, multi-location retailers can use in-store/in-mall video kiosks to provide promotional and product information to shoppers. Video kiosks are also an efficient and cost-effective way for retailers to deliver messages and informative video content to their clientele. The same kiosks can also receive video broadcasts for employee training. In addition to the commercial applications for kiosk systems, public information is also being sent to kiosks. For example, in the aftermath of Hurricane Andrew in 1995, disaster relief officials implemented kiosks to provide needed information during the relief effort.

These and other innovative video and multimedia services will be provided by SpaceCast™. This highly flexible and cost effective system will bring many new services and benefits to consumers.

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Systems Description

4. SYSTEM DESCRIPTION

4.1. General Overview of the System

4.1.1 Spectrum

The SpaceCast™ system will utilize 3 GHz of uplink and downlink spectrum at V-band with dual polarization. It will also utilize 500 MHz of uplink and downlink spectrum at Ku-band with dual polarization. It will re-use the V-band spectrum up to 40 times per satellite and Ku-band spectrum up to eight times per satellite.

HCI acknowledges that certain portions of the Ku-band identified in Section 4.2 below are already in use at certain orbital positions that HCI has proposed for SpaceCast™. HCI expressly does not seek authority to use any portion of the Ku-band at any orbital position where that portion is unavailable.[2] The existing uses of portions of the Ku-band at different orbital positions and the differences in the allocations for these bands around the world are the reasons why HCI has specified a range of Ku-band frequencies currently allocated for the FSS of which it proposes to use 500 MHz at each orbital position (a range of 12.75-13.25 and 13.75-14.5 GHz in the uplink band and 10.7-12.75 GHz in the downlink band). While each SpaceCast™ satellite will be capable of operating across this entire range, in order to simplify

[2] The 12/14 GHz band is available for assignment at 125° W.L. as of the end of the useful life of GSTAR II. *See Assignment of Orbital Locations to Space Stations in the Domestic Fixed Satellite Service*, DA 96-713 (released May 7, 1996), Appendix.

satellite construction and provide maximum in-orbit redundancy, it actually will operate at each assigned position only on the spectrum that is available for licensing there.

4.1.2 Terminals

Customers' needs will be met by a family of small dishes, from 45 cm to 1 meter (18 - 39 inches) for receive-only operation to 2.5 meter for two-way use, as described in Figure 4.10.3-1. Receive-only terminals can be dual frequency mode or single frequency mode.

4.1.3 Coverage

The SpaceCast™ system will cover regions in North America, Europe, and Asia, as shown in Appendix C. The system will use four orbital positions: 125° W, 60° W, 39° W, and 155° E. Each satellite will cover high demand areas via up to 40 spot beams at V-band and will provide additional coverage via up to 16 large area beams at Ku-band. Laser ISLs will interconnect SpaceCast™ satellites to allow direct routing between satellites.

4.2. FREQUENCY PLAN

Figure 4.2-1 shows an overview of the frequency and polarization plan for the SpaceCast™ system. As shown in Figure 4.2-1a, V-band communications will take place in the 47.2-50.2 GHz (Earth-to-space) and 39.5-42.5 GHz (space-to-Earth) bands. SpaceCast™ can provide up to 40 V-band beams and up to 16 Ku-band beams. This achieves 40 times reuse of the V-band spectrum and eight times reuse of the Ku-band spectrum. These beams can be deployed or redeployed within the coverage area of the satellite depending on market demand. Antenna tracking beacons will be at the lower edges of the V-bands and Ku-bands.

Figure 4.2-1b shows the frequency plan for Ku-band communications. The planned Ku-bands are used for illustrative purposes. 500 MHz of spectrum in the 12.75-13.25 GHz and/or 13.75-14.25 GHz uplink band and the 10.7-12.75 GHz downlink band will be utilized. Up to 16 elliptical beams will be used with 250 MHz of bandwidth to minimize beam-to-beam interference. The Ku-band spectrum will be reused up to eight times per satellite.

Figure 4.2-1c shows the plan for command, telemetry, ranging, and tracking beacons. All of these functions will take place at Ku-band, using approximately 2 MHz of bandwidth near the lower edges of the uplink and downlink bands.

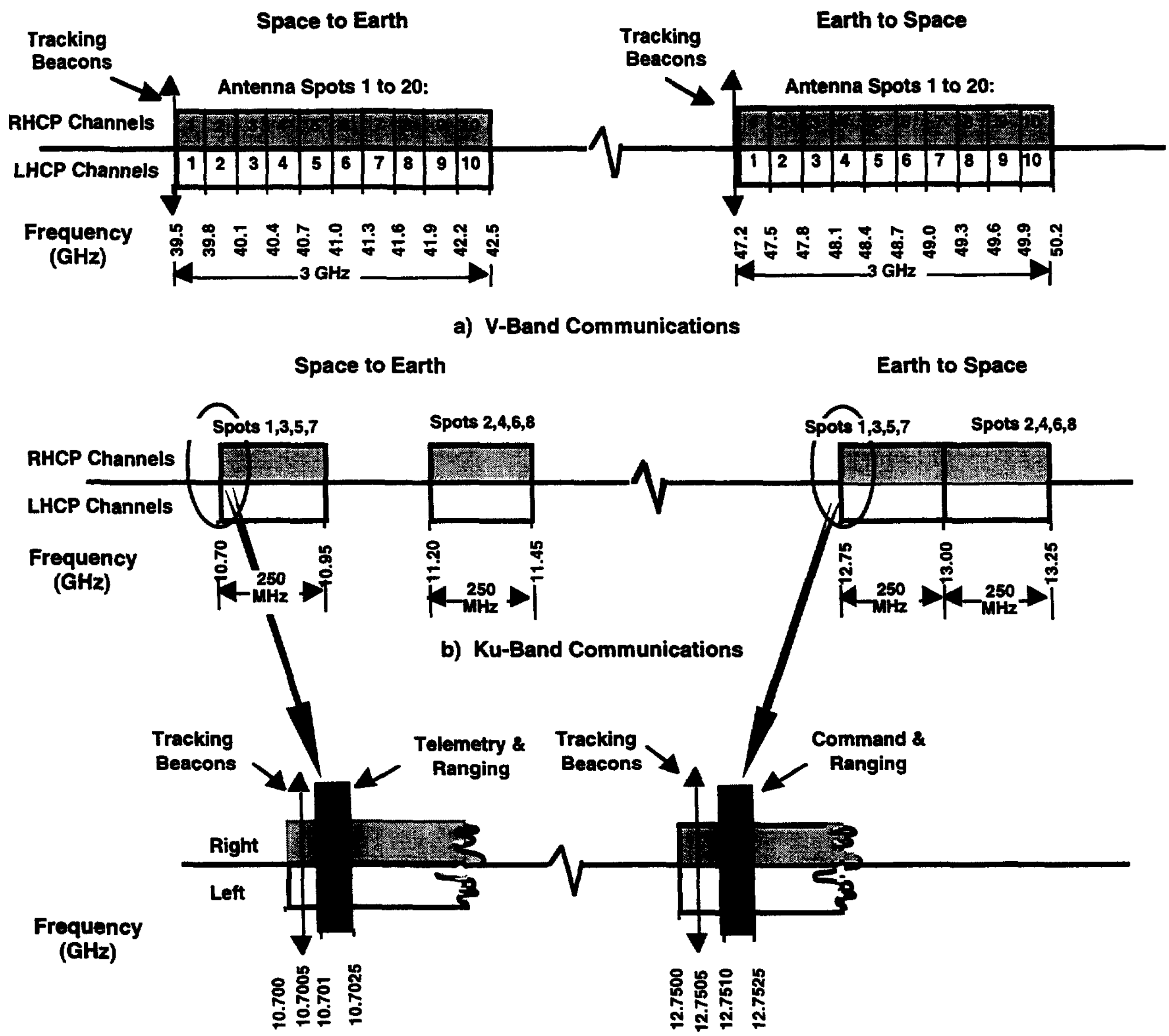

Figure 4.2-1. Illustrative Frequency & Polarization Plan

Figures 4.2-2 and 4.2-3 show the detailed frequency and polarization plans for V-band communications. The 3 GHz of spectrum will be used in each of two polarizations and will be channelized into ten 300-MHz wide frequency division multiplexed (FDM) channels, each of which are time division multiplexed (TDM) into 100 time channels or slots. Users will be assigned a unique time slot and FDM channel and will, in general, burst data at 155 Mbps. All uplink time slots and all downlink time slots are synchronized to a satellite clock that controls channel-to-channel switching and connectivity by means of a satellite TDMA switch. Because up to 40 beams will be active at any given time, and because each beam is capable of supporting 4,000 channels of compressed, 384 kbps video, the total V-band capacity is 160,000 channels of compressed, multiplexed 384 kbps video per satellite.

Ku-band communications will use an approach similar to that of V-band. Figures 4.2-4 and 4.2-5 show the detailed frequency and polarization plans for the Ku-band, using the planned Ku-band for illustrative purposes. Again, the bandwidth will be used in each of two polarizations[3] and 100 time slots will be time division multiplexed onto a single uplink or downlink carrier to provide a total Ku-band capacity of 6400 channels of compressed 384 kbps video.

[3] Thus, by employing dual polarization, SpaceCast™ effectively meets the full-frequency reuse requirements of Sections 25.210(c) and (e) of Commission's Rules. As is the case with the Ka-band, the Commission, in modifying its existing service rules to facilitate licensing in the V-band, should allow use of dual circular polarization, instead of dual linear polarization. In order to facilitate use of the same type of polarization for both the Ku-band and V-band on SpaceCast™ and to the extent necessary, HCI requests a waiver of the vertical and horizontal polarization requirements of Section 25.210(c).

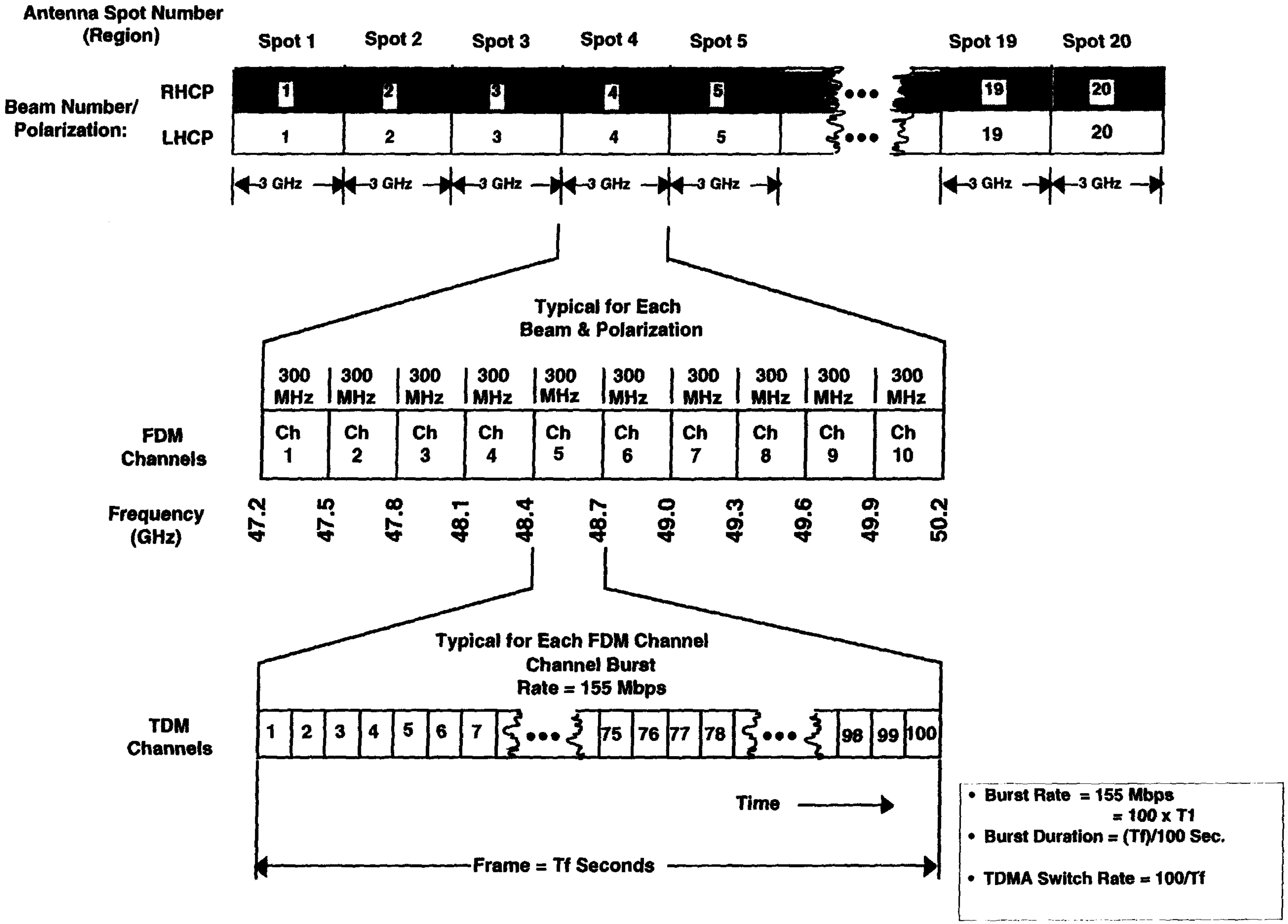

Figure 4.2-2. V-Band Uplink (Earth-to-Space) Frequency and Polarization Plan

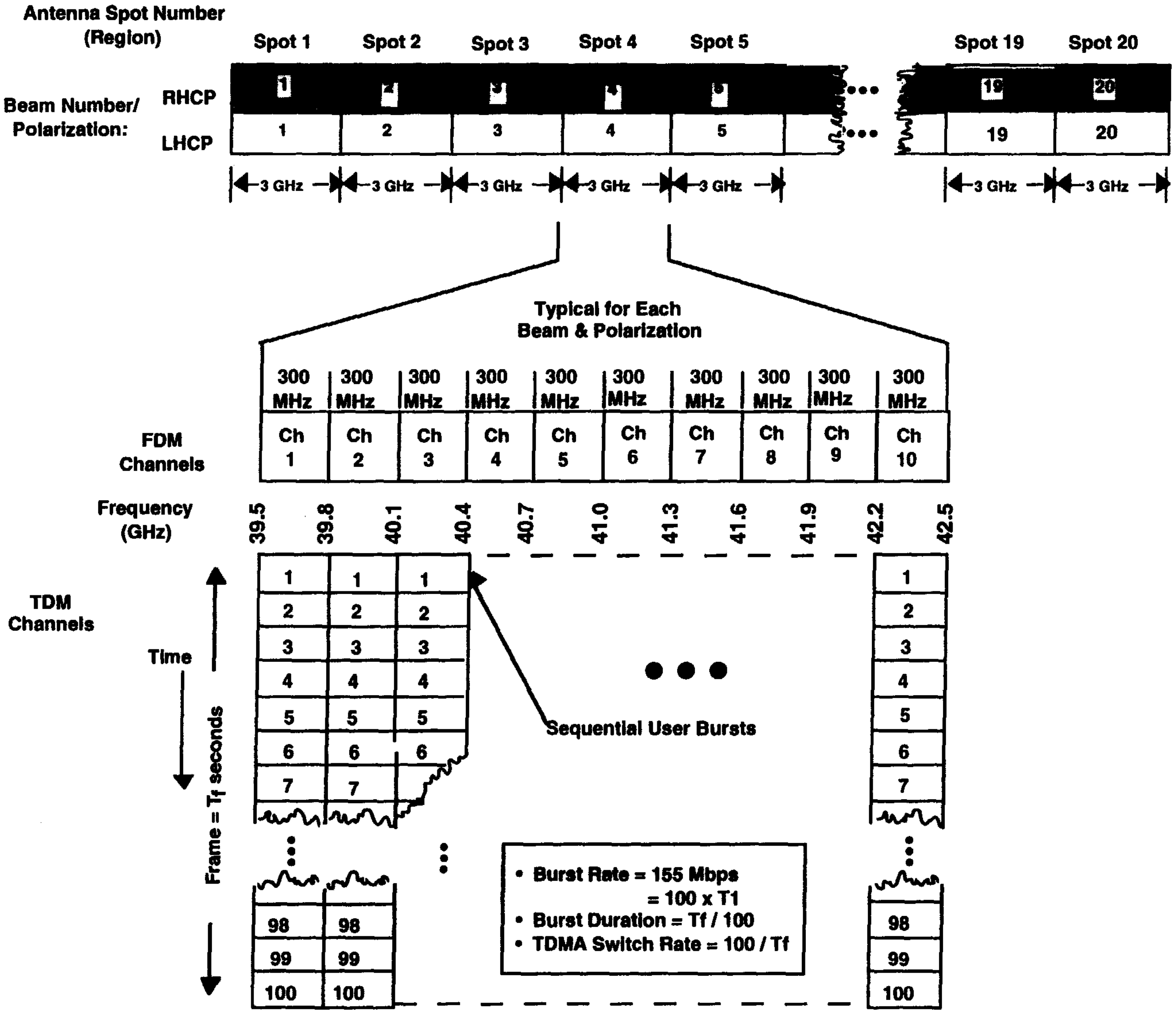

Figure 4.2-3. V-Band Downlink (Space-to-Earth) Frequency and Polarization Plan

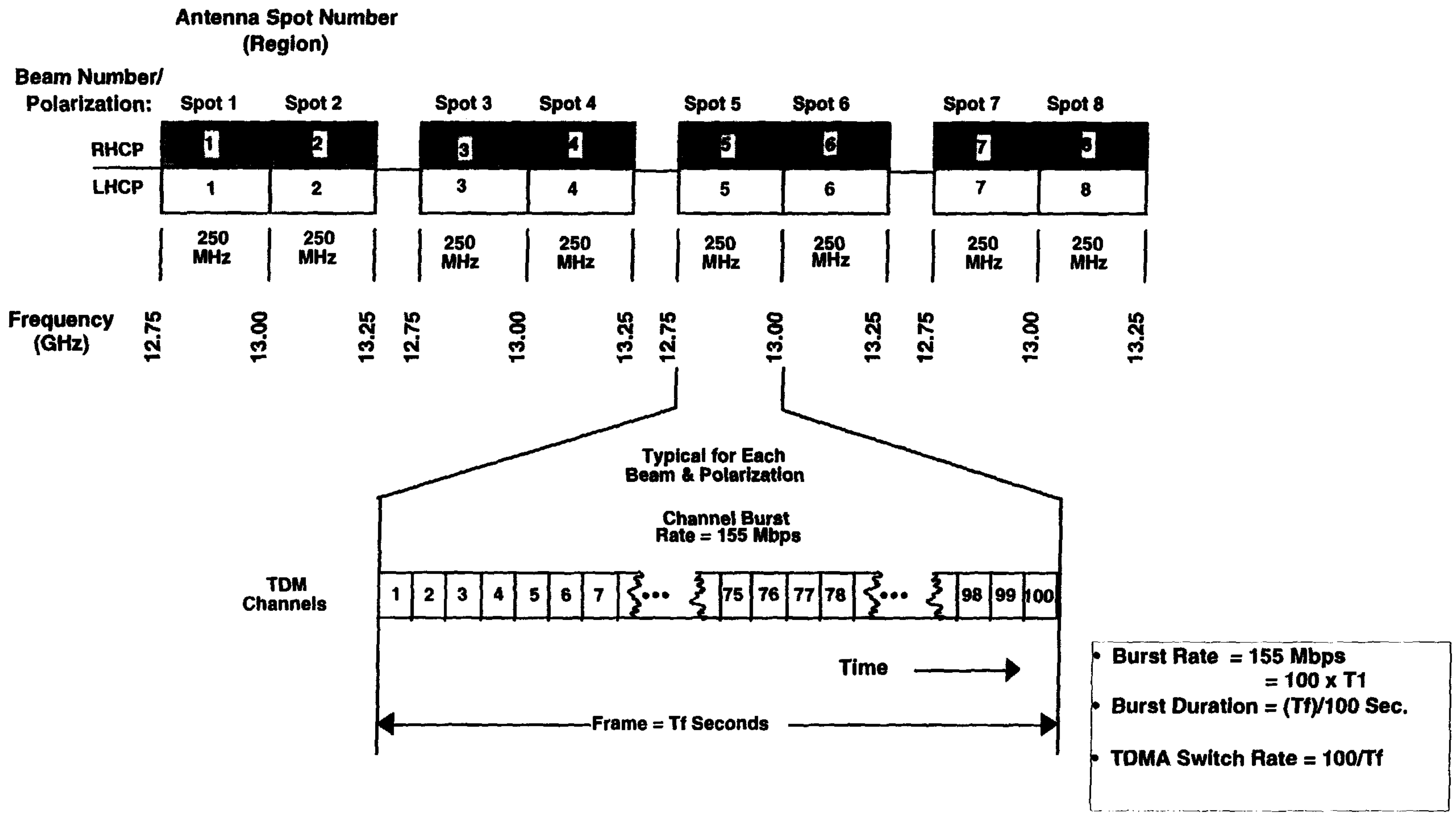

Figure 4.2-4. Ku-Band Communications Uplink (Earth-to-Space) Frequency and Polarization Plan (Specific Frequencies are Illustrative)

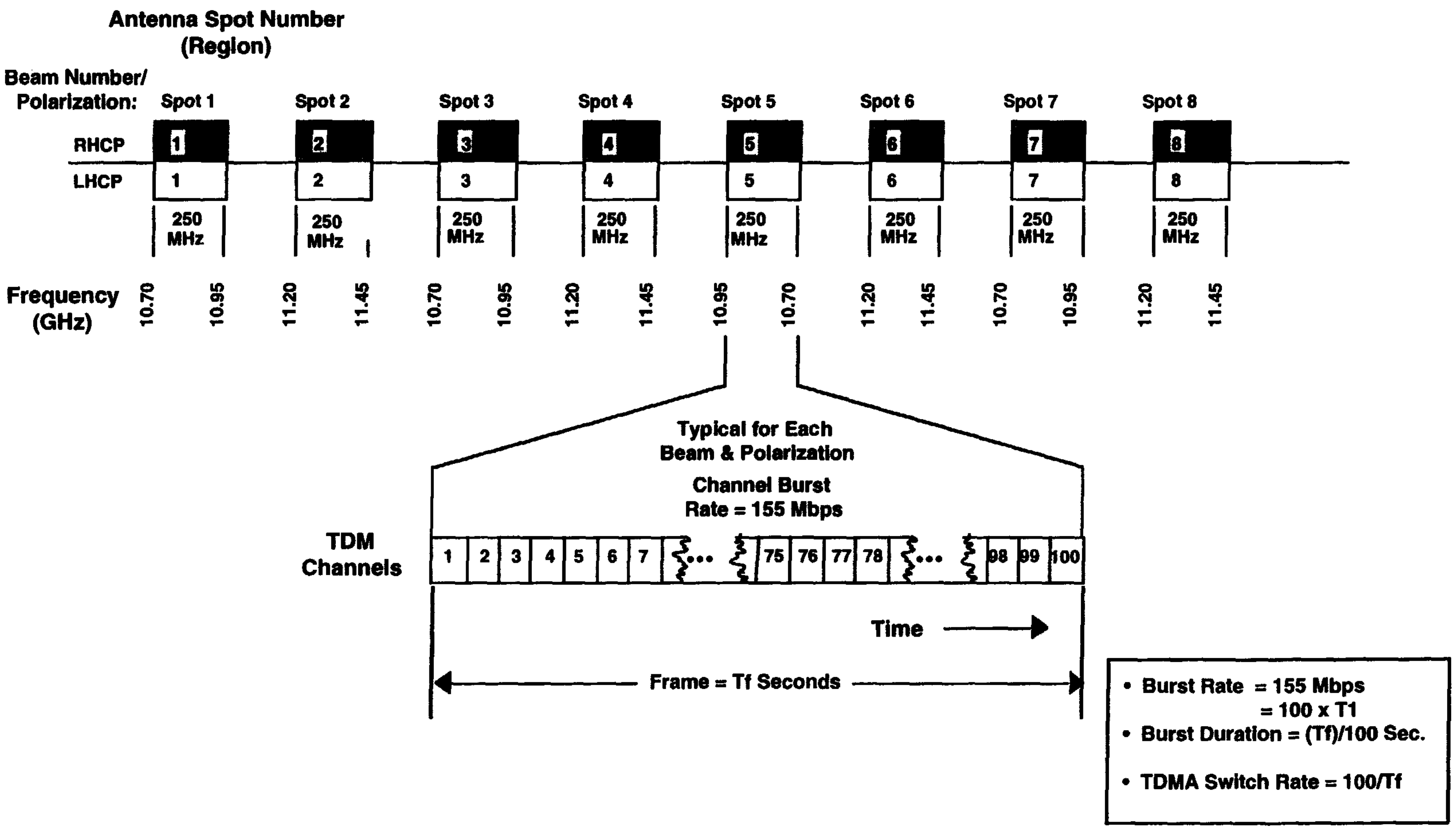

Figure 4.2-5. Ku-Band Communications Downlink (Space-to-Earth) Frequency and Polarization Plan (Specific Frequencies are Illustrative)

4.3. Emission Designators

Uplink V-band communications to SpaceCast™ satellites will use a Pulse Code Modulation, Differential Quadriphase Shift Keying (PCM/DQPSK) format. Each V-band beam will contain ten 300 MHz-wide frequency division multiplexed (FDM) channels. Each FDM channel will in turn be time shared (TDM) by 100 users with a burst rate as high as 155 Mbps. Downlink communications will also use a PCM/DQPSK format.

Each Ku-band uplink communications beam will have a single 250 MHz carrier time shared by users using the same PCM/DQPSK modulation format. Users will burst data to the satellite at a rate as high as 155 Mbps. Each downlink carrier will use the PCM/DQPSK format in a continuous, non-burst mode.

Commands to the satellites from the earth control segment will be performed at Ku-band using Non-Return-to-Zero/Frequency-Shift-Keying/Frequency Modulation (NRZ/FSK/FM) modulation. Range tones transmitted to the satellite on the Ku-band command carrier will be transponded and phase modulated onto the downlink Ku-band telemetry carrier. Telemetry data will be transmitted using a Pulse Code Modulation/Phase-Shift-Keying/Phase Modulation (PCM/PSK/PM) format. Unmodulated Ku-band and V-band beacons will also be transmitted to and from the satellites for attitude control and pointing. Command, telemetry, ranging, tracking, and beacons will occupy lower edges of the uplink and downlink Ku-bands. Table 4.3-1 lists the various signals as well as their emission designators.

Table 4.3-1 Emission Designators

Signal	Number Per Beam	Emission Designator
V-band Communications Uplink	10	257MG1DDT
V-band Communications Downlink	10	257MG1DDT
V-band Communications Uplink	10	43M7G1DDT
V-band Communications Downlink	10	43M7G1DDT
Ku-band Communications Uplink	1	214MG1DDT
Ku-band Communications Downlink	1	214MG1DDT
Ku-band Command	1	1M50F9DXF
Ku-band Telemetry	1	1M50G9DXF
Ku-band Receive Beacons	1	100KN0NXN
Ku-band Transmit Beacons	1	100KN0NXN
V-band Receive Beacons	1	100KN0NXN
V-band Transmit Beacons	1	100KN0NXN

4.4. Power Flux Density Compliance

4.4.1. V-Band Communications

At present, no power flux density (PFD) requirement is specified in the FCC Rules for emissions in the 39.5-42.5 GHz band used by SpaceCast™ for communications downlink. The international Radio Regulations (RR) have specified limits applicable to this band. Using these requirements, emissions from a satellite shall not exceed: (a) -115 dB (W/m^2) in any 1 MHz band for angles of arrival between 0 and 5 degrees above the horizontal plane; (b) -115 + 0.5(d-5) (W/m^2) in any 1 MHz band for angles of arrival d (degrees) between 5 and 25 degrees above the horizontal plane; (c) -105 dB (W/m^2) in any 1 MHz band for angles of arrival between 25 and 90 degrees above the horizontal plane.

Because signal burst rates range from 26.418 Mbps to 155.52 Mbps and because the satellite EIRP per carrier is constant regardless of the burst rate, the maximum PFD in any 1 MHz band is determined by the narrowest signal's bandwidth:

PFD (dBW/m^2/MHz) = Satellite Carrier EIRP (dBW) - 20 log(Slant Range in km) - 71 - 10 log (43.7 MHz/1 MHz)

Table 4.4.1-1 gives the SpaceCast™ V-band maximum PFD as a function of elevation angle. In all cases SpaceCast™ complies with the limits with at least 2 dB margin for all elevation angles above the horizon.

Table 4.4.1-1. V-Band Communications Maximum Power Flux Densities

Maximum PFD Requirement ($dBW/m^2/MHz$)	Elevation Angle (degrees)	Slant Range (km)	SpaceCast™ Power Flux Density ($dBW/m^2/MHz$)	Margin (dB)
-115	0	41,680	-117.8	2.8
-115	5	41,128	-117.7	2.7
-105	25	39,072	-114.2	9.2
-105	90	35,787	-113.5	8.5

4.4.2. Ku-Band Communications

4.4.2.1 FCC Rules

PFD at the earth's surface produced by a satellite for all methods of modulation shall not exceed: (a) -150 $dB(W/m^2)$ in any 4 kHz band for angles of arrival between 0 and 5 degrees above the horizontal plane; (b) -150 + (d-5)/2 $dB(W/m^2)$ in any 4 kHz band for angles of arrival (in degrees), between 5 and 25 degrees above the horizontal plane; and (c) -140 $dB(W/m^2)$ in any 4 kHz band for angles of arrival between 25 and 90 degrees above the horizontal plane. A single Ku-band carrier will be used to support TDM data rates up to 155 Mbps in a 250 MHz beam. Because a 155 Mbps carrier occupies a bandwidth of 214 MHz, the Ku-band PFD in any 4 kHz band is given by:

PFD ($dBW/m^2/4$ kHz) = Satellite Carrier EIRP (dBW) - 20 log(Slant Range in km) - 71 - 10 log (214 MHz/4 kHz)

Table 4.4.2.1-1 gives the SpaceCast™ PFD as a function of elevation angle. In all cases, SpaceCast™ complies with the PFD limits with more than 4 dB margin for angles up to 25° above the horizon and with more than 10 dB for angles above 25°.

Table 4.4.2.1-1. FCC Ku-Band Communications Power Flux Densities

Maximum PFD Requirement (dBW/m²/4 kHz)	Elevation Angle (degrees)	Slant Range (km)	SpaceCast™ Power Flux Density (dBW/m²/4 kHz)	Margin (dB)
-150	0	41,680	-154.4	4.4
-150	5	41,128	-154.3	4.3
-140	25	39,072	-150.8	10.8
-140	90	35,787	-150.1	10.1

4.4.2.2 International Requirements

International PFD limits applicable to SpaceCast™'s Ku-band downlink transmission were taken from RR S21.16. The power flux densities at the Earth's surface produced by emissions from a satellite for all conditions and for all methods of modulation shall not exceed the following for frequencies between 10.7 GHz and 11.7 GHz: (a) -150 dB(W/m^2) in any 4 kHz band for angles of arrival between 0 and 5 degrees above the horizontal plane; (b) -150 + 0.5(d-5) dB(W/m^2) in any 4 kHz band for angles of arrival d (in degrees) between 5 and 25 degrees above the horizontal plane; and (c) -140 dB(W/m^2) in any 4 kHz band for angles of arrival between 25 and 90 degrees above the horizontal plane. Table 4.4.2.2-1 gives the SpaceCast™ Ku-band PFD in any 4 kHz band. As shown in this table, SpaceCast™ therefore complies with the international Radio Regulations by more than a 4 dB margin.

Table 4.4.2.2-1. International Ku-Band Communications Power Flux Densities (10.7-11.7 GHz)

Maximum PFD Requirement (dBW/m²/4 kHz)	Elevation Angle (degrees)	Slant Range (km)	SpaceCast™ Power Flux Density (dBW/m²/4 kHz)	Margin (dB)
-150	0	41,680	-154.4	4.4
-150	5	41,128	-154.3	4.3
-140	25	39,072	-150.8	10.8
-140	90	35,787	-150.1	10.1

Under RR S21.16, the power flux densities at the earth's surface produced by emissions from a satellite for all conditions and for all methods of modulation shall not exceed the following for frequencies between 12.2 and 12.75 GHz: (a) -148 dB(W/m^2) in any 4 kHz band for angles of arrival between 0 and 5 degrees above the horizontal plane; (b) -148 + 0.5(d-5) dB(W/m^2) in any 4 kHz band for angles of arrival d, between 5 and 25 degrees above the horizontal plane; and (c) -138 dB(W/m^2) in any 4 kHz band for angles of arrival between 25 and 90 degrees above the horizontal plane. Table 4.4.2.2-2 gives the SpaceCast™ Ku-band PFD in any 4 kHz band. As shown in this table, SpaceCast™ complies with the international Radio Regulations by more than a 6 dB margin.

Table 4.4.2.2-2. International Ku-Band Communications Power Flux Densities (12.2-12.75 GHz)

Maximum PFD Requirement (dBW/m^2/4 kHz)	Elevation Angle (degrees)	Slant Range (km)	SpaceCast™ Power Flux Density (dBW/m^2/4 kHz)	Margin (dB)
-148	0	41,680	-154.4	6.4
-148	5	41,128	-154.3	6.3
-138	25	39,072	-150.8	12.8
-138	90	35,787	-150.1	12.1

4.4.3. Ku-Band Telemetry

4.4.3.1. FCC Rules

SpaceCast™ telemetry will take place in the lower 2 MHz of selected Ku-bands. The maximum EIRP for the telemetry downlink as given in Appendix A of this application is 8.0 dBW. Using the same criteria as that for Ku-band communications given in Section 4.4.2.1 above, the maximum telemetry PFD in any 4 kHz band is given by the expression below and tabulated in Table 4.4.3.1-1.

PFD (dBW/m²/4 kHz) = Satellite EIRP (dBW) - 20 log(Slant Range in km) - 71

- 10 log (1.5 MHz/4 kHz)

As shown in Table 4.4.3.1-1, the PFD for SpaceCast™ telemetry complies with the Commission limits with at least 30 dB of margin for all elevation angles above the horizon.

Table 4.4.3.1-1. FCC Ku-Band Telemetry Power Flux Densities

Maximum PFD Requirement (dBW/m²/4 kHz)	Elevation Angle (degrees)	Slant Range (km)	SpaceCast™ ™ Power Flux Density (dBW/m²/4 kHz)	Margin (dB)
-150	0	41,680	-181.0	31.0
-150	5	41,128	-180.9	30.9
-140	25	39,072	-180.4	40.4
-140	90	35,787	-179.7	39.7

4.4.3.2 International Requirements.

Using the same criteria as those for Ku-band communications given in Section 4.4.2.2 above, SpaceCast™ telemetry compliance with international PFD limits was determined and is given in Tables 4.4.3.2-1 and 4.4.3.2-2 below. As shown, SpaceCast™ telemetry complies with the international PFD limits with a margin of more than 30 dB for all elevation angles above the horizon in the 10.7-11.7 GHz band and more than 32 dB for all elevation angles above the horizon in the 12.2-12.75 GHz band.

Table 4.4.3.2-1. International Ku-Band Telemetry Power Flux Densities (10.7-11.7 GHz)

Maximum PFD Requirement (dBW/m²/4 kHz)	Elevation Angle (degrees)	Slant Range (km)	SpaceCast™ ™ Power Flux Density (dBW/m²/4 kHz)	Margin (dB)
-150	0	41,680	-181.0	31.0
-150	5	41,128	-180.9	30.9
-140	25	39,072	-180.4	40.4
-140	90	35,787	-179.7	39.7

Table 4.4.3.2-2. **International Ku-Band Telemetry Power Flux Densities (12.2-12.75 GHz)**

Maximum PFD Requirement ($dBW/m^2/4$ kHz)	Elevation Angle (degrees)	Slant Range (km)	SpaceCast™ ™ Power Flux Density ($dBW/m^2/4$ kHz)	Margin (dB)
-148	0	41,680	-181.0	33.0
-148	5	41,128	-180.9	32.9
-138	25	39,072	-180.4	42.4
-138	90	35,787	-179.7	41.7

4.4.4. Tracking Beacons

Two unmodulated Ku-band tracking beacons will be used for satellite attitude control and antenna pointing and will be located near lower edges of the Ku-band spectrum. Two beacons will also be provided near lower edges of the V-band spectrum. The satellite beacons will have a maximum EIRP of 12 dBW.

4.4.4.1 FCC Rules

Table 4.4.4.1-1 provides PFD levels for the Ku-band tracking beacons.

Table 4.4.4.1-1. FCC Ku-Band Beacon Power Flux Densities

Maximum PFD Requirement ($dBW/m^2/4$ kHz)	Elevation Angle (degrees)	Slant Range (km)	SpaceCast™ Power Flux Density ($dBW/m^2/4$ kHz)	Margin (dB)
-150	0	41,680	-151.4	1.4
-150	5	41,128	-151.3	1.3
-140	25	39,072	-150.8	10.8
-140	90	35,787	-150.1	10.1

4.4.4.2. International Requirements.

SpaceCast™ beacon compliance with international PFD regulations are shown in Tables 4.4.4.2-1, 4.4.4.2-2, and 4.4.4.2-3.

Table 4.4.4.2-1. International V-Band Beacon Power Flux Densities

Maximum PFD Requirement ($dBW/m^2/MHz$)	Elevation Angle (degrees)	Slant Range (km)	SpaceCast™ Power Flux Density ($dBW/m^2/MHz$)	Margin (dB)
-115	0	41,680	-151.4	36.4
-115	5	41,128	-151.3	36.3
-105	25	39,072	-150.8	45.8
-105	90	35,787	-150.1	45.1

Table 4.4.4.2-2. International Ku-Band Beacon Power Flux Densities (10.7-11.7 GHz)

Maximum PFD Requirement ($dBW/m^2/4kHz$)	Elevation Angle (degrees)	Slant Range (km)	SpaceCast™ Power Flux Density ($dBW/m^2/4\ kHz$)	Margin (dB)
-150	0	41,680	-151.4	1.4
-150	5	41,128	-151.3	1.3
-140	25	39,072	-150.8	10.8
-140	90	35,787	-150.1	10.1

Table 4.4.4.2-3. International Ku-Band Beacon Power Flux Densities (12.2-12.75 GHz)

Maximum PFD Requirement ($dBW/m^2/4kHz$)	Elevation Angle (degrees)	Slant Range (km)	SpaceCast™ Power Flux Density ($dBW/m^2/4\ kHz$)	Margin (dB)
-148	0	41,680	-151.4	3.4
-148	5	41,128	-151.3	3.3
-138	25	39,072	-150.8	12.8
-138	90	35,787	-150.1	12.1

4.5. SPACE SEGMENT

The Hughes high power spacecraft supports the power and antenna mounting area required for SpaceCast™. This satellite is a three-axis, body-stabilized satellite that uses a five panel solar array system, along with outboard radiator panels attached to the main body to dissipate heat generated from the high power TWTs. Table 4.5-1 gives satellite characteristics, and Figure 4.5.-1 is an illustration of the satellite.

Table 4.5-1. SpaceCast™ Satellite Characteristics

Satellite Bus	Hughes High Power Spacecraft
Mission Life	15 Years End-of-Life
Stabilization	3 Axis Earth Sensor and Beacon Tracking with the Use of Reaction Wheels and Thrusters
DC Power	17 kW Beginning-of-Life (5 Panel Design) 15 kW End-of-Life
Eclipse Capability	100%
Deployed Length	Approximately 144 Feet (5 Panel Design)
Approximate Weight	5500 kgs with Propellant 3500 kgs without Propellant
V-band Antennas	2 V-Band Reflectors 2 Feed Horn Packs
Ku-band Antennas	2 Reflectors 2 Feed Horn Packs
T&C Antennas	2 Ku Bicone Receive/Transmit 4 Pipe Antennas Receive/Transmit
Beacon Tracking	Command Planar Array and/or V-band Service Link
Number of V-band FDM Carriers	400
Number of V-band Antenna Footprints	204
V-band Cross-Polarization Isolation	30 dB
Number of Active, V-band Antenna Beams	Maximum of 40
Number of Ku-band FDM Carriers	16 active
Number of Ku-band Footprints	up to 16
Ku-band Cross-Polarization Isolation	30 dB
Number of CMD Carriers	2
Number of TLM Carriers	2
Number of Tracking Beacons	2 Transmit, 2 Receive at Ku-band 2 Transmit, 2 Receive at V-band
Number of Laser Carriers	2 Transmit, 2 Receive
V-Band Spectrum Reuse	40 times
Ku-Band Spectrum Reuse	8 times
Station Keeping North-South East-West	 ± 0.05° ± 0.05°
Antenna Pointing Normal (Precision Two Axis RF Beacon Tracking)	 ± 0.03° N-S and E-W

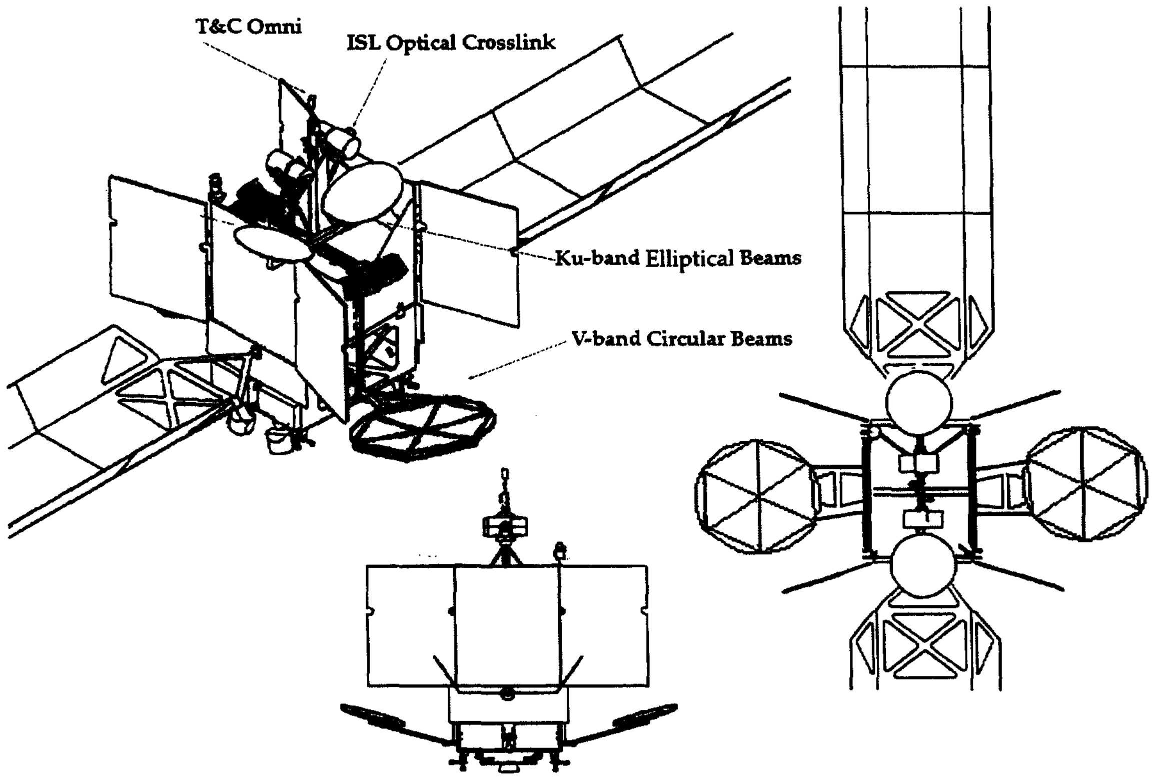

Figure 4.5-1 Hughes High Power Satellite

4.5.1. Communications Subsystem

The satellites contain both V-band and Ku-band payloads. Payload management and reconfiguration will be performed via SpaceCast™'s TT&C system operating in conjunction with the system's ground operations and control segment (See Section 4.10). Table 4.5.1-1 gives communication parameters, and Appendix A provides illustrative link budgets.

Table 4.5.1-1. Communication Parameters

Parameter Description	V-Band Payload	Ku-Band Payload	Crosslink Payload
Modulation Format	DQPSK	DQPSK	Intensity, Wavelength, Multiplexed
Coding Scheme	Convolutional Concatenated Reed Solomon	Convolutional Concatenated Reed Solomon	Convolutional Concatenated Reed Solomon
Target Bit Error Rate	1×10^{-9}	1×10^{-9}	1×10^{-9}
Max Data Rates/FDM Channel	155 Mbps	155 Mbps	3 Gbps
FDM Channel Bandwidth	300 MHz	250 MHz	N/A
Uplink / Downlink / Crosslink Total Bandwidth	3 GHz	500 MHz	N/A

4.5.1.1. V-Band Subsystem

The V-band subsystem will utilize 3 GHz of spectrum (47.2 to 50.2 GHz) for Earth-to-space communication and 3 GHz of spectrum (39.5 to 42.5 GHz) for space-to-Earth communication. The V-band antenna system will consist of multibeam feed horn arrays and reflectors. Appendix C contains V-band antenna coverage plots for satellites located at requested orbital positions. Any satellite in the constellation can independently select a maximum of 40 active beams out of an array of 204 possible spot beam footprints. The spectrum of a single beam will be divided into ten 300 MHz wide FDM channels, including guard bands. Each 300 MHz TDM channel will be time division multiplexed (FDM) by 100 channels or time slots. The overall format is PCM/DQPSK on each uplink and downlink beam. Figure 4.5.1.1-1 shows the V-band/Ku-band satellite payload block diagram.

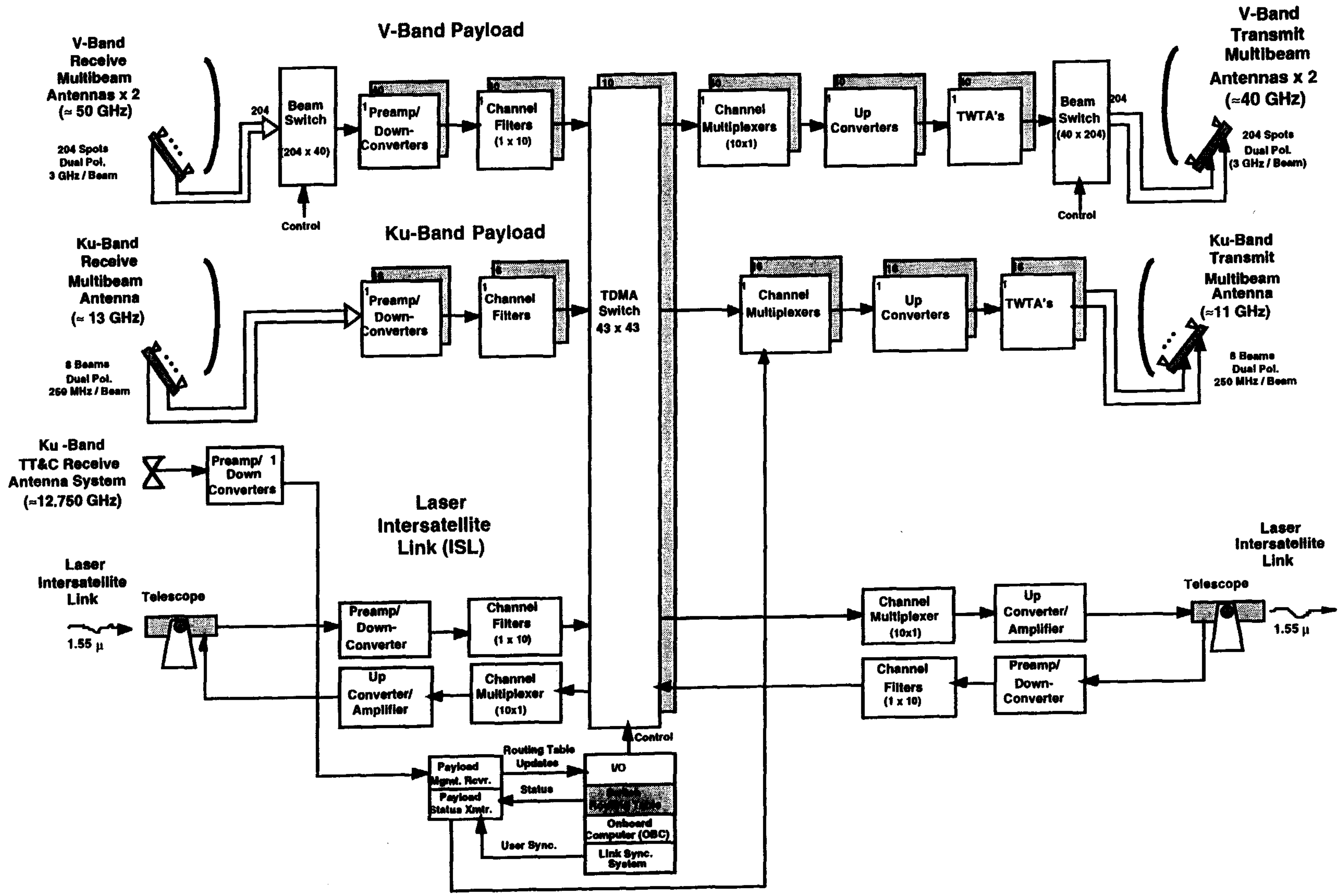

Figure 4.5.1.1-1. V/Ku-Band Repeater Block Diagram (Specific Ku-band Frequencies are Illustrative)